(a) 1.0 to 3.49 wt% of Ag;

(b) 0.4. To 0.99 wtT of Cu;

(c) 0.02 to 0.06 wt% of Ni;

(d) 0.02 to 0.06 wt% of Fe; and

(e) a balance of Sn;

wherein said combination Ni and Fe serves to lower a copper dissolution rate of said solder

9. (TWICE AMENDED) A lead-free solder consisting of:

(a) 1.0 to 3.49 wt% of Ag;

(b) 0.4 to 0.99 wt% of Cu;

(c) 0.02 to 0.06 wt% of Fe; and

(d) a balance of Sn;

wherein said Fe serves to lower a copper dissolution rate of said solder.

REMARKS

The claims 1-14 are pending herein.

Claims 15-20 are cancelled herewith since they have been refiled in a divisional application.

The specification has been amended to provide a separate brief description for each of the figures with an alphabetical suffix.

The remainder of the rejection in the Office Action (Paper No. 7) relates to an overlapped range of the composition relative to the composition set forth in the prior art.

Claim 1 has been amended both to include its dependent Claim 7 and to remove the overlapped range of the composition. The addition of Ni and Fe reduce copper leaching or dissolution and does not raise the boiling point of the solder. Also, the addition of these constitutions causes a reduction of the wt% of Ag. Hence, the addition of Fe to Claim 1, in effect, reduces the percentage of Ag in the total composition. Since silver (Ag) is a very expensive material, any reduction of it in the total composition is an important cost saving. Claim 9 has also been amended to remove the overlap. Therefore, the cited art does not anticipate the claims.

Environmental pollution occurs when equipment having lead solder (Pb) is scrapped. Therefore, the recent explosion in the amount of electronic equipment which is scrapped with many soldered joints has made it important to eliminate the lead solder, especially in electronic devices.

The prior art has tended to develop lead free solder made of a Tin (Sn)-Silver (Ag)-Copper (Cu) alloy. However, solder made from such an alloy has two problems. First, Ag is very expensive relative to other solder materials; hence, it should be minimized. Second, lead free solder has caused "copper leaching" where the copper strips on a printed circuit board or the like tend to dissolve, thus reducing the width and thickness of the copper layer, which increases the electrical resistance of the strip line. This, in turn, causes a localized heating and thermal fatigue (specification page 4, line 15, et seq.).

Another disadvantage of the prior art lead free solder is that the melting temperature becomes excessively high (page 5, lines 15-24). That, in turn, causes many other problems.

Hence, the applicants' invention is designed to provide a lead free solder, with a low melting point and a low level of copper leaching, while maintaining highly reliable solder joints, and minimizing the amount of silver in the solder. The "copper leaching" is primarily reduced by an inclusion of nickel (Ni) or Iron (Fe) in the alloy, preferably at a rate of 0.02-0.06 wt% (page 7, lines 22-24; page 11, line 20, et seq; page 14, lines 7-9).

After all of these technical considerations are satisfied, the chief consideration is to reduce the amount of expensive silver that is required.

Applicants claims are for a combination or alloy of Ag, Cu, Ni and/or Fe and Sn in specifically named ranges. The characteristics of the resulting alloys will be different from the characteristics of some other alloys with other ranges and other constituent materials. Applicants' position is that no cited art includes an alloy having these named ranges Therefore, applicants' claims are not anticipated by the cited art.

Copper (Cu) is an element for suppressing the "copper leaching" (page 17, line 14 et seq). Applicants state that this suppression is insufficient if Cu is less than 0.4 wt% of the alloy and the liquidus temperature of the solder is too high when Cu is greater than 1.3 wt% (page 18, lines 9-16). Table 3 on page 18 shows the data on the liquidus temperature and the copper dissolution rate as the copper content increases from 0 to 0.5 wt%.

Table 4 (page 19) shows the copper dissolution rates for alloys having 0-5 wt% Ag and 0-1.6 wt% Cu. From page 21, lines 4-21, the best results are produced when Ni is in the range of 0.02-0.06 wt%. From page 22, lines 1-11; 23, we find the same range of 0.02-0.06 wt% for Fe. If both Ni and Fe are added to the alloy, the preferred Ni range is

either 0.02-0.06 wt % or 0.02-0.04 wt% and the Fe range is 0.02-0.06 wt% or 0.02-0.05 wt% (page 23, lines 7-10).

The many tables and other statistics found in the applicants' specification make it abundantly clear that the Pb free solder is an alloy or composition having constituents selected in different ratios in order to produce a desired combination of liquidus temperature, reduction of copper leaching, strength of soldered joints and the like.

The claims stand rejected over the following references:

U.S.P.	4,643,875
U.S.P.	6,139,979
JP	09-94688
JP	10-034376
DE	19 816 671
WO	98-34755

U.S. Patent 4,643,875 ('875)

The first reference to a composition in '875 is found in Col. 1, lines 37-49. There is no Fe. There is titanium, vanadium, and zirconium. In Col. 1, lines 53-55, there is no Fe and there is Zirconium. In Col. 1, lines 65-67; Col. 2, lines 13,14; the silver is 5%,the copper is 1.25% and there is titanium. In Col. 2, line 33, the silver is 15%, the copper 15% and titanium 2%. This analysis process may be repeated throughout '875 and it will be found that none of the formula disclosed in '875 matches the claimed formula.

U.S. Patent 6,139,979 ('979)

There is no Fe in any of the formula of the '979 patent. In col. 1, line 66, there is 0.5 to 5.0% of antimony. The expensive '979 metals (Col. 2, lines 13-16 and 39-44) are a totally different class of materials.

From '979 Table 1 (Cols. 5, 6), only samples 9-12 have the combination Ni, Ag, Cu. In each of the samples 9-11, Ni is 0.15% and in sample 12 it is 0.40. Applicants' Ni does not go over 0.06%. There is no Fe. Antimony appears in each of the '979 claims.

JP 09-94688 ('688)

The '688 Ag range 3.5-7.7 is outside of applicants' claimed range. The Cu range 1.0-4.0 is outside applicants' claimed range. The '688 alloy does not have either Ni or Fe.

JP 10-034376 ('376)

The '376 formula includes bismuth and phosphorous, which is not in applicants' formula.

DE 19 816 671 ('671)

The '671 formula includes antimony, germanium, and phosphorous, none of which is in applicants' formula.

An IDS is filed by an accompanying paper. This IDS includes a European Patent Office search report, and the references cited by them. The only two references marked by an "X" are GB 2 346 380 A and WO 98/34755, meaning that the searcher considered only them important. The remainder of the cited references are marked by "A" which means that the searcher considered them to be of background interest and did not consider them close enough to support rejection.

GB 2 346 380A ('380)

British '380 does not have any disclosure of the ranges claimed by application. Perhaps the closest disclosure of applicants claimed alloy appears to be on page 2, lines 5-8, as follows:

	'380	Applicants' Claims
Ag	0.5-2.89 wt%	1.0-3.49 wt.%
Cu	0.5-2.0 wt%	0.4-0.99 wt %
Ni	0.01-0.5 wt%	0.02-0.06 wt%
Fe	None	0.02-0.06 wt%
Bal. Sn	Yes	Yes

This '380 alloy does not include Fe. As will become more apparent, these data, in effect, say that '380 does not anticipate the invention.

British '380 has acceptable alloys in Table 1 (Page 10), none of which has Fe. Only Table 1 samples 9-12 have Ni-Ag-Cu. In each of these samples in Table 1, the nickel content (0.15 and 0.40) is above applicants' ranges of 0.02-0.99. Moreover, '380 describes 0.01-0.05 wt% Ni (Page 2, line 6), but Cu is 0.5 to 2.0 wt%. Applicants teach that, if Ni is less than 0.02 wt% the reduction of copper leaching is insufficient (Page 21, line 12). British '380 teaches that if the lower limit is less than 0.01, the electrode erosion resistance decreases. (Page 3, lines 28, 29) Applicants teach that, if Ni is greater than 0.06 wt% the liquid temperature is too high (Page 21, lines 8-11).

British '380 teach that bonding strength is not improved when Cu is less than 0.5 wt% and decreases if higher than 2.0 wt% (Page 4, lines 8, 9). Applicants teach that the

lower limit for Cu is 0.4 wt% and the higher limit not greater than 1.3 wt% (Page 18, lines 13-16).

For solder wetting, applicants teach that (Page 17, lines 4-12), if Ag is less than 1.0 wt%, it shortens the wetting time and if greater than 4.0 wt% increases the liquidus temperature to excessively high levels. British '380 says that if the Ag content is less than 0.5 wt% bonding is not improved or higher than 3.39 wt% bonding is decreased (Page 4, lines 20-22). Clearly, applicants and British '380 are teaching different things.

Hence, it is apparent that the claimed range of the constituents of the two solders are non-overlapping. The two written disclosures set forth different criteria for and selection of upper and lower limits for each of the constituents in the alloy. Hence, the two disclosures are for different alloys and are not in conflict.

WO 98/34755 ('755)

This patent lists its alloy on page 11, as follows:

WO 98/34755	Applicants
Ag 3.5–7.7 wt%	1.0-3.49 wt%
Cu 1.0-4.0 wt%	0.4-0.99 wt%
Ni 0.3-0.15 wt%	0.02-0.06 wt%

Claim 3 takes Ag up to 7.7 wt%; Cu up to 4 wt%; Ni or Fe to 0.5 wt%.

It seems apparent that the '755 alloy is completely different from applicants' alloy.

Clearly, the alloy of the claimed invention is different from the various alloys that are set forth in the cited art. The applicants believe that their solder is different from and superior to the solder disclosed in the cited art.

In greater detail, each of applicants' claims includes Ni and/or Fe in the range of 0.02 to 0.06 wt%. None of the cited references have this range of Ni and/or Fe. Please see Applicants' prior amendment with a 7/23/01 certificate of mailing for a summary of the constituents of the alloys in the cited art.

The search for a better Pb free solder is not merely a matter of optimizing the basic formula. There are other very important considerations, an improvement of any one of these considerations may be a giant step forward: improved electrical soldered joints, reduced copper leaching, reduced use of silver, etc.

While the reliability of some soldered electrical joints (e.g., TV, VCR, DVD players, etc) may be less important, the reliability of other soldered electrical joints is critical and crucial (e.g., radar, earth satellites, guidance systems, and the like). Failures in such critical equipment could lead to airliners crashing, missiles going off course, communication failures in times of national emergencies, and the like. For these and other reasons, alloys in the applicants' field is not merely a matter of optimization.

All of these considerations must be accomplished while reducing the cost of the solder. Considering the number of joints that are required, a simple thing, such as the cost of solder, becomes a limiting factor. Hence, a reduction of silver is an important step forward.

It should be apparent that, if the presently cited art is in anticipation of applicants' claims almost no alloys will ever be patentable. The fact that so many prior art references were cited with similar formula is proof that different formula are patentable. Otherwise, the first person to disclose an alloy would prevent any one from ever getting a patent on a similar alloy.

For the foregoing reasons, it is thought that the application is in condition for allowance. However, if the Examiner believes otherwise, he is respectfully requested to telephone the undersigned attorney before issuing a new Office Action. Any reasonable necessary amendments will be made promptly.

Reconsideration and allowance are requested.

Respectfully submitted,

Dated: 8/7/02

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IN THE SPECIFICATION:

Page 9, line 18 through Page 10, line 13:

[Figs. 2A to 2E are graphs showing the results of experiments of the sample solders in Tables 11 to 15 under the condition that the Cu content is changed from 0.2 to 1.6 wt% and the Ni content is changed from 0 to 0.2 wt% while the Ag content is fixed at 0.5, 1, 3.5, 4, or 5 wt% respectively.

Figs. 3A to 3E are graphs showing the result of experiments of the sample solders in Tables 11 to 11 under the condition that the Ag content is changed from 0.2 to 1.6 wt% and the Ni content is changed from 0 to 0.1 wt% while the Cu content is fixed at 0.2, 0.4, 0.8, 1.2, and 1.6 wt% respectively.

Figs. 4A to 4E are graphs showing the result of experiments of the sample solders in Tables 11 to 15 under the condition that the Cu content is changed from 0.2 to 1.6 wt% and the Fe content is changed from 0 to 0.1 wt% while the Ag content is fixed 0.5, 1, 3.5, 4, and 5 wt% respectively.

Figs. 5A to 5E are graphs showing the result of experiments of the sample solders in Tables 11 to 15 under the condition that the Ag content is changed from 0.2 to 1.6 wt% and the Fe content is changed from 0 to 0.1 wt% while the Cu content is fixed at 0.2, 0.4, 0.8, 1.2, and 1.6 wt% respectively.]

Fig. 2A is a graph showing the results of experiments with samples of solder having Ag, Cu, and Ni where Ag is 0.5 wt %;

Fig. 2B is a graph showing the results of experiments with samples of solder having Ag, Cu, Ni where Ag is 1 wt %;

Fig. 2C is a graph showing the results of experiments with samples of solder having Ag, Cu, and Ni where Ag is 3.5 wt %;

Fig. 2D is a graph showing the results of experiments with samples of solder having Ag, Cu, and Ni where Ag is 4 wt %;

Fig. 2E is a graph showing the results of experiments which shows the results of experiments with samples of solder having Ag, Cu, and Ni where Ag is 5 wt %;

Fig. 3A is a graph showing the results of experiments with samples of solder having Cu, Ag, and Ni where Cu is 0.2 wt %;

Fig. 3B is a graph showing the results of experiments with samples of solder having Cu, Ag, and Ni where Cu is 0.4 wt %;

Fig. 3C is a graph showing the results of experiments with samples of solder having Cu, Ag, and Ni where Cu is 0.8 wt %;

Fig. 3D is a graph showing the results of experiments with samples of solder having Cu, Ag, and Ni where Cu is 1.2 wt %;

Fig. 3E is a graph showing the results of experiments with samples of solder having Cu, Ag, and Ni where Cu is 1.6 wt %;

Fig. 4A is a graph showing the results of experiments with samples of solder having Ag, Cu, and Fe where Ag is 0.5 wt %;

Fig. 4B is a graph showing the results of experiments with samples of solder having Ag, Cu, and Fe where Ag is 1 wt %;

Fig. 4C is a graph showing the results of experiments with samples of solder having Ag, Cu, and Fe where Ag is 3.5 wt %;

Fig. 4D is a graph showing the results of experiments with samples of solder having Ag, Cu, and Fe where Ag is 4 Wt %;

Fig. 4E is a graph showing the results of experiments with samples of solder having Ag, Cu, and Fe where Ag is 5 wt %;

Fig. 5A is a graph showing the results of experiments with samples of solder having Cu, Ag, and Fe where Cu is 0.2 wt %;

Fig. 5B is a graph showing the results of experiments with samples of solder having Cu, Ag, and Fe where Cu is 0.4 wt %;

Fig. 5C is a graph showing the results of experiments with samples of solder having Cu, Ag, and Fe where Cu is 0.8 wt %;

Fig. 5D is a graph showing the results of experiments with samples of solder having Cu, Ag, and Fe where Cu is 1.2 wt %;

Fig. 5E is a graph showing the results of experiments with samples of solder having Cu, Ag, and Fe where Cu is 1.6 wt %;

IN THE CLAIMS:

Please amend Claim 1, as follows:

1. (AMENDED) A lead-free solder consisting [essentially] of:

(a) 1.0 to [4.0] 3.49 wt% of Ag;

(b) 0.4. to [1.3] 0.99 wt% of Cu;

(c) 2 to 0.06 wt% of Ni;[and]

(d) 0.02 to 0.06 wt% of Fe; and

(e) a balance of Sn;

wherein said Ni serves to lower a copper dissolution rate of said solder

Please amend Claim 9, as follows:

9. (AMENDED) A lead-free solder consisting [essentially] of:

(a) 1.0 to [4,0] 3.49 wt% of Ag;

(b) 0.4 to [1.3] 0.99 wt% of Cu;

(c) 0.02 to 0.06 wt% of Fe; and

(d) a balance of Sn;

wherein said Fe serves to lower a copper dissolution rate of said solder.